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PROGRAMMATIC PESTICIDE EVALUATION REPORT AND SAFER USE ACTION PLAN (PERSUAP) GLOBAL FALL ARMYWORM MANAGEMENT

PROJECT/ACTIVITY

Project/Activity Name:	Global Fall Armyworm Programmatic PERSUAP
Amendment #:	3
Geographic Location:	Global
Implementation Start/End:	May 2019 - April 2024
BFS Tracking ID of this Action:	BFS-19-05-001
BFS Tracking ID of Original IEE and Amendment #2:	Original IEE: Feed the Future Innovation Lab for Integrated Pest Management Program (approved 9/29/2014) Amendment #2: BFS-17-05-002, FtF IPM IL Amendment Programmatic Africa FAW PERSUAP (approved 5/16/17) https://ecd.usaid.gov/repository/pdf/50065.pdf

ORGANIZATIONAL/ADMINISTRATIVE DATA

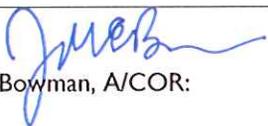
Implementing Operating Unit:	BFS/ARP
Other Affected Units:	USAID Field Missions and Bureaus affected by FAW
Funding Accounts:	DA, Title II, IDA, TI, ESF
Lead BEO Bureau:	BFS
Lead Editor:	Bill Thomas, BFS Bureau Environmental Officer
Date Prepared:	May 30, 2019

ENVIRONMENTAL COMPLIANCE REVIEW

Analysis Type:	§216.3(B) Pesticide Procedures - PERSUAP
Pesticide Procedures Expiration Date:	April 2024
Additional Analyses/Reporting Required:	Affected Mission pesticide analysis and country-specific SUAP

This Programmatic PERSUAP is intended to be utilized by USAID Field Missions and Pillar Bureaus in support of Fall Armyworm (*Spodoptera frugiperda*) management under regular or emergency funding. U.S. Government funding to purchase or otherwise enable the use of the pesticides listed in this document requires adherence to all conditions and mitigating measures contained within. This is an Amendment to the USAID/BFS IPM IL IEE, and an update of the May 2017 Programmatic Africa FAW PERSUAP, version 1, approved by AFR, BFS & DCHA Bureau Environmental Officers. All other conditions, limitations and stipulation for revisions of the original IEE are unchanged and remain legally binding. In accordance with Title 22, Code of Federal Regulations, Part 216 (22 CFR 216) and Automated Directives System Chapter 204, the conditions and requirements of this document become mandatory upon approval and shall be transposed into all relevant procurement documents and actions.

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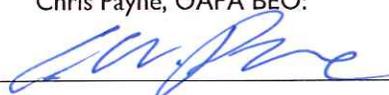
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Programmatic Global Fall Armyworm Pesticide Evaluation Report and Safer Use Action Plan

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I.0 Introduction

This Programmatic Global Fall Armyworm Pesticide Evaluation Report and Safe Use Action Plan (hereafter FAW P-PERSUAP) is intended to assist USAID Missions to support Fall Armyworm (FAW) management operations. Herein find FAW basic biology, distribution, an array of Integrated Pest Management (IPM) options, e.g., biological control, pesticides, and genetically engineered organisms -- with a strong focus on Integrated Pest Management) and guidance to develop a pesticide safer use action plan (SUAP).

This FAW P-PERSUAP is an Amendment of, and update to, the USAID/BFS IPM IL IEE, and an geographic extension of the May 2017 Programmatic Africa FAW PERSUAP approved by the Bureau Environmental Officers from BFS, AFR, and DCHA. This document is intended to be utilized by USAID Field Missions and Pillar Bureaus in the support of FAW management where U.S. Government (USG) funding may be allocated for the purchase of, or otherwise to enable the use of, pesticides listed in this document. As such, any aspect of pesticide procurement, use, or both, requires the full adherence to conditions, mitigating, monitoring and reporting measures contained in this document. This is best accomplished by having Implementing Partners develop a robust and field appropriate Safer Use Action Plan. Pesticides can only be procured, used, or both, when the Mission Environmental Officer (MEO), in collaboration with the appropriate Bureau Environmental Officer (BEO) and Regional Environmental Adviser (REA), together with cognizant Assistance/Contracting Officer's Representative (A/COR) certify (in GLAAS) that pesticides intended for use, are both listed herein, and registered in the host country where use is intended. Certification should be done by the MEO together with the cognizant A/COR and in collaboration with the appropriate BEO and REA, at which time certification shall be manifested in GLASS that the requested pesticides have been approved by this FAW P-PERSUAP.

Conditions and guidance in this document shall be followed when US funds procure and/or use pesticides for control of FAW and a primary condition is that only pesticides listed in this document and registered in the host country are allowable. It is the responsibility of the A/COR, or Activity Manager if duly designated, to ensure that the use of pesticides listed in this document follow FAW P-PERSUAP pesticide procedures (per §216.3(b)), and develop a SUAP. In many cases, the MEO should be available to assist.

2.0 **Mandatory Conditions** for USAID Missions and Bureaus:

1. **Read this PERSUAP.** Review the basic information on this insect and potential management options, the listed pesticides, and the safer use action plan section and consider applicability to your situation.
2. **Appraise the non-chemical options** described in this document as appropriate for your country and project/activity specific situation, in particular the awareness, training, monitoring, and specifically the scouting techniques and tool provided in the FAW Working Group's Pest Management Decision Guide (PMDG) in Annex 1 (and below on this page).
3. **Evaluate the list of pesticides** in Section 8.0 on page 18, to choose pesticides most appropriate for your country and crop situation.
4. The A/COR and MEO are responsible for ensuring that any pesticide considered from this document is also **registered with the host country** and is appropriate for the specific crop and conditions;
5. Ensure that an active **SUAP** is developed to support FAW control operations per the guidance in this document prior to operational initiation. Work with the A/COR and MEO, with assistance from REA and BEO as needed.
6. Make sure to **document and keep a good record** of all pesticide use, management decisions, and any other pesticides supported by USG funds. See Annex 5.
7. All conditions approved in this FAW P-PERSUAP shall be appropriately inserted by Mission Office of Acquisition and Assistance (OAA) into **procurement instruments**. When the procurement of pesticides approved in this FAW P-PERSUAP transpires under the existing contracts or awards, OAA shall seek to promptly modify existing procurement instrument to appropriately adapt and insert the relevant conditions from the FAW P-PERSUAP.
8. At either the pre-award briefing or post-award conference, A/COR and MEO shall explain the **conditions of this P-PERSUAP**.
9. The FAW P-PERSUAP may be used concurrently and in support of other Mission approved Programmatic PERSUAPs and other PERSUAPs, as well as all current and valid Pillar and Regional Bureaus Programmatic PERSUAPs.
10. Lastly, Mission personnel should note that changing precipitation and weather patterns together with increased global trade can contribute to the rapid spread of this pest across continents and countries, potentially posing significant damage threats to food security and could impede the journey to self-reliance in many developing countries. Missions should monitor the spread and/or emergence of FAW in their countries using local sources and the global resources enumerated below.
11. In some cases, existing bilateral Agricultural sector PERSUAPs merely need to be amended with the content of the present FAW P-PERSUAP.

3.0 Review the Excellent Existing Information on the Fall Armyworm:

There is now a significant amount of exceptional information on this insect pest that can greatly help affected Missions, host governments, and Implementing Partners (IP). In addition to this FAW P-PERSUAP, utilize the information listed below to work with appropriate in-country entities to build a strong FAW management program appropriate for country conditions.

1. **USAID Agrilinks FAW page** at Feed the Future Tools to Combat Fall Armyworm has a variety of excellent resources, videos and training materials.
 - <https://www.agrilinks.org/post/feed-future-tools-combat-fall-armyworm-africa>
2. Review and share with the host government and relevant implementing partners, the **Fall Armyworm Integrated Pest Management Guide** to ensure that IPM is part of the overall management strategy in your country. This excellent resource is now in French and Portuguese as well as English.
 - https://www.usaid.gov/sites/default/files/documents/1867/Fall-Armyworm-IPM-Guide-for-Africa-Jan_30-2018.pdf

3. The **USAID Feed the Future Fall Armyworm Information Page** has links to Country-specific Pest Management Decision Guides (PMDG) for over 30 countries, often in other languages than English, as well as other USAID FAW resources. These emphasize least toxic yet effective pesticides for use by low-resource farmers with minimal protection equipment and training. The PMDGs also include Scouting forms on the back to help determine decision thresholds before deciding to treat with pesticides. Some of the available PMDG are attached to this document in Annex I. Refer to the link below for all available PMDG.
 - <https://www.agrilinks.org/post/feed-future-tools-combat-fall-armyworm-africa>
4. The **USAID Fall Armyworm Tech Prize Winners** have some amazing ideas for the technical transfer of digital tools and approaches which can provide timely and context-specific information to enable smallholder farmers to identify, treat, and track incidence of fall armyworm.
 - <https://fallarmywormtech.challenges.org/winners/>
5. The **United Nations Food and Agriculture Organization (FAO) Fall Armyworm Information Page** has up-to-date information on the FAW, management guidance documents, videos, training manuals, FAW distribution, and updated briefing notes.
 - <http://www.fao.org/fall-armyworm/en/>
6. The **CABI Fall Armyworm Information Portal and Data Sheet** has the latest information on FAW, including photos, identification description and guidance, training manuals, videos, distribution, host plants and vulnerable crops, natural enemies, and management guidance.
 - CABI FAW Info Portal: <https://www.cabi.org/isc/fallarmyworm>
 - CABI FAW Data Sheet: <https://www.cabi.org/isc/datasheet/29810>
7. Review the **Scientific Animations Without Borders (SAWBO) Fall Armyworm video library** and download / adapt to your country.
 - <https://sawbo-animations.org/video.php?video=//www.youtube.com/embed/5rxlpXEK5g8>
8. A recent scientific publication describes **where the FAW will likely strike next**:
 - Regan Early, Pablo González-Moreno, Sean T. Murphy, Roger Day. *Forecasting the global extent of invasion of the cereal pest Spodoptera frugiperda, the fall armyworm*. NeoBiota, 2018; 40: 25 DOI: 10.3897/neobiota.40.28165
 - <https://www.sciencedaily.com/releases/2019/01/190109090927.htm>
9. The **International Maize and Wheat Improvement Center (CIMMYT) and Cereal Systems Initiative for South Asia (CSISA)** recently (May 2019) put out a series of excellent and highly recommended **Infographics on the Fall Armyworm**.
 - Fall Armyworm Life Cycle
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-FAW_life_cycle_final-NXPowerLite-Copy.pdf
 - What is Fall Armyworm and why is it a threat?
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-FAW_overview_final-NXPowerLite-Copy.pdf
 - What is the Fall Armyworm and how can I scout for it in my field?
 - i. <https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-PostCard-3-FAW-Surveillance-NXPowerLite-Copy.pdf>
 - What should I do if I find Fall Armyworm damage?
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512_FAW_control_final.pdf

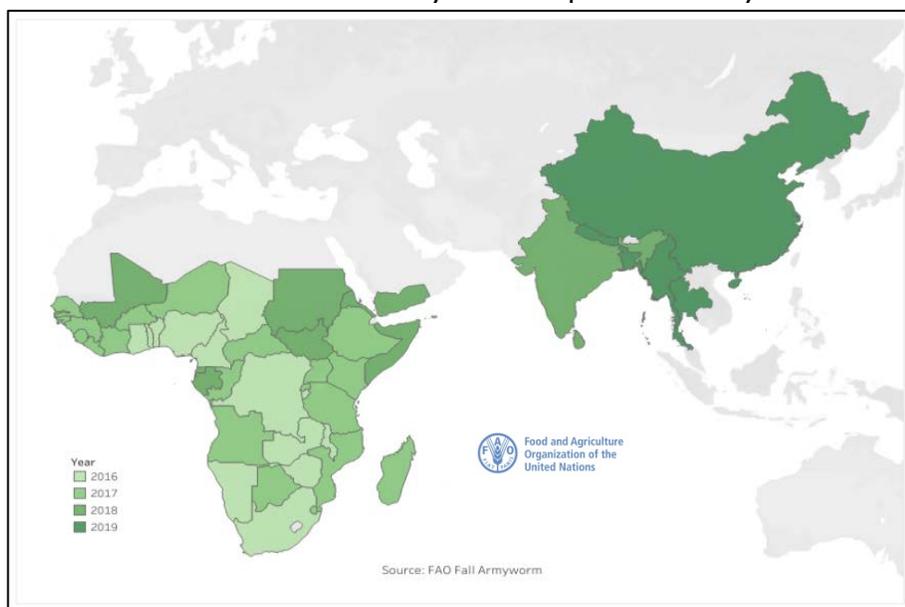
4.0 THE FALL ARMYWORM

The FAW, *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is native to the tropics in North and South America. It is polyphagous (able to feed on various kinds of plants) and an economically important pest of maize, sorghum, sugarcane, groundnut and other crops. Depending on the degree of infestation, FAW can cause huge losses, especially in maize yield and in some cases, total crop loss. In North America, the FAW will move north in the late summer and early fall, which is when it does most of its damage. It then dies off in the cold weather. In maize, it affects all stages of plant development and is difficult to control. The pest can survive year around in warm and humid climates.

4.1 DISTRIBUTION

Outside of the Americas, the FAW appears to have been first detected in Africa (Nigeria) in January 2016, likely arriving on a passenger flight from the America's. This insect was first correctly identified by the International Institute of Tropical Agriculture in Ibadan, Nigeria. It apparently spread to other West African countries and into Central Africa by April 2016 and to East Africa by April 2017. To date, FAW outbreaks have been reported in all the Sub-Saharan Africa, Yemen, India, Sri Lanka, Bangladesh, Myanmar, southern China, Thailand, Cambodia, and Vietnam. FAW has not yet been reported, but may also be present in other

neighboring countries. The FAW strain in Togo appears to be the haplotype found in southern Florida and the Caribbean. The source of the FAW is important for two reasons: 1) different haplotypes have different host ranges; 2) different biotypes carry different pesticide resistance genes. The estimated loss due to this pest in Africa was USD13.38 billion (CABI 2017). This FAO map shows areas affected by fall armyworm in April 2019.



4.2 HOST PLANTS

The FAW has a wide host range with over 300 plant species. Its preferred host plants are maize, sorghum, millet, rice, wheat, sugar cane, and Bermuda grass. This pest also attacks other non-graminaceous crops such as cow pea, groundnut, soy bean, cotton, potato, apple, grape, orange, papaya, peach, strawberry and a number of ornamental plants. Invasive plant species known to serve as hosts include bentgrass, Johnson grass, morning glory, nutsedge, crabgrass, pigweed and sandspur.

Maize is an important cereal crop and staple food for many people around the world. It was domesticated in Mesoamerica during prehistoric times. In the late fifteenth century, it was brought to Europe and other countries. Maize spread to the rest of the world due to its ability to thrive in diverse climates. Maize is a very important staple crop in Africa – more than 300 million Africans depend on it as their main food source (maize is also an economic source for millions of farmers across Africa). Out of 53 countries in sub-Saharan Africa, 46 countries cultivate maize. Africa's top maize producers are South Africa, Nigeria and Ethiopia. Maize has become major crop in China surpassing rice in total production and it is the third important crop in India after rice and wheat.

4.3 LIFE CYCLE

Eggs are dome shaped and are dirty white to gray in color. Eggs are laid in groups or clusters of about 10-200 eggs per egg mass. Sometimes the eggs are deposited in layers but usually eggs are laid in a single layer attached to foliage. After oviposition, the female deposits a layer of grayish scales or hairs over the eggs and covers the egg mass giving it a hairy or moldy appearance. Depending on conditions, eggs hatch in two to five days in summer.



Figure 1 Fall Armyworm eggs (bugguide.net)

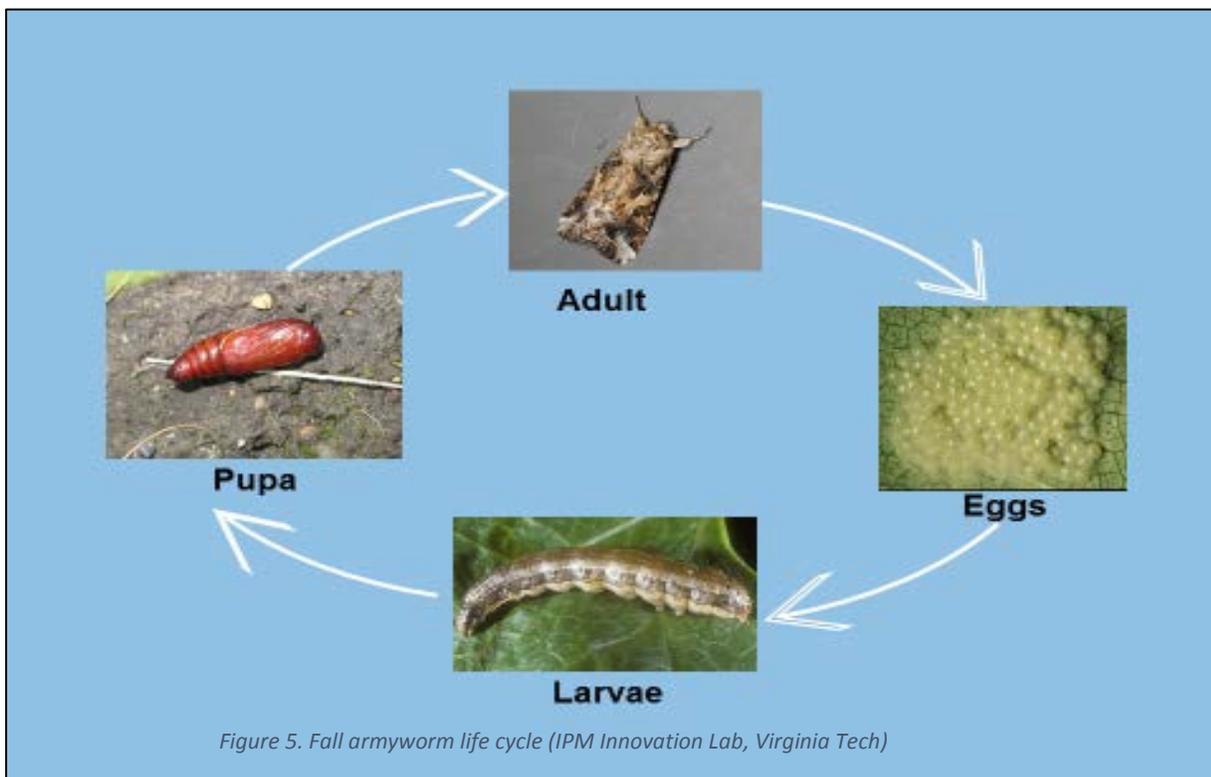
In its native regions, FAW goes through six larval stages, with the newly hatched larvae greenish with a black head, which turns orange-brown in the second instar. Newly hatched larvae feed near where the egg mass was laid then move up onto the maize plants and consume leaf tissue. The larvae can exhibit cannibalistic behavior, and under heavy infestations, larval densities can be reduced to one or two per plant. Fully-grown larvae are 3.1 – 3.8 cm long and vary in color from pale green to almost black, with three yellowish stripes running down the back. There is a wider dark stripe and a wavy yellow-red blotched stripe on each side. The FAW's head has a predominant white, inverted Y-shaped suture between the eyes. Duration of the larval stage tends to be about fourteen days during the summer and 30 days during cool weather.



Figure 3: Fall Armyworm larva displaying Y-shaped suture (Holly Schwarting, Kansas State Research and Extension)



Figure 4: Fall Armyworm larva displaying yellowish stripes on side (bugguide.net)



Pupation normally takes place in the soil at a depth of 2-8 cm. The pupa is reddish brown in color with summer duration of 8-9 days, and longer than two weeks under winter conditions. The adult moths have a wingspan of 32 - 40 mm. The male moth has dark gray and brown shaded, mottled forewings with conspicuous triangular white spots at the tip and near the center of the wing. These markings are less distinct in female moths. The hind wing is iridescent silver-white with a narrow dark border in both sexes. Adults are nocturnal, and are most active at dusk (for mating). Females deposit most of their eggs during the first four to five days of life, but some eggs may be laid for up to three weeks. Adults can live up to an average of ten days but sometimes the duration extends up to three weeks. The larvae are nocturnal feeders. Unlike other armyworm species, FAW are typically found damaging maize in patches throughout a field. In the U.S., they appear in maize fields late in the season, from mid-July through the fall harvest, but the timing may be different in other parts of the world due to climatic differences.



Figures 6 & 7: Fall armyworm adults: female, male
 (John L. Capinera, University of Florida, Kansas State University)

In summer months, the FAW completes its life cycle in about 30 days; however during winter months it takes 80 - 90 days to complete its life cycle. The number of generations in an area varies with the appearance of the dispersing adults. This species does not have the ability to diapause, instead exhibits the tendency to continuously breed when conditions are favorable. It follows a typical lepidopteran life cycle of egg, larva, pupa and adult.

4.4 IDENTIFICATION

Easy to follow PMDG identification factsheets and a poster for use by extension officers and farmers to help identify the FAW in Africa have been produced by CABI Plantwise in conjunction with national Ministries of Agriculture Plant Protection Services. Additional information from CABI's and third party sources can be accessed through the open access Plantwise knowledge bank:

<http://www.plantwise.org/KnowledgeBank/SearchResults.aspx?q=Spodoptera%20frugiperda>

The CABI Invasive Species Compendium provides open access information on the pest:

<http://www.cabi.org/isc/datasheet/29810>

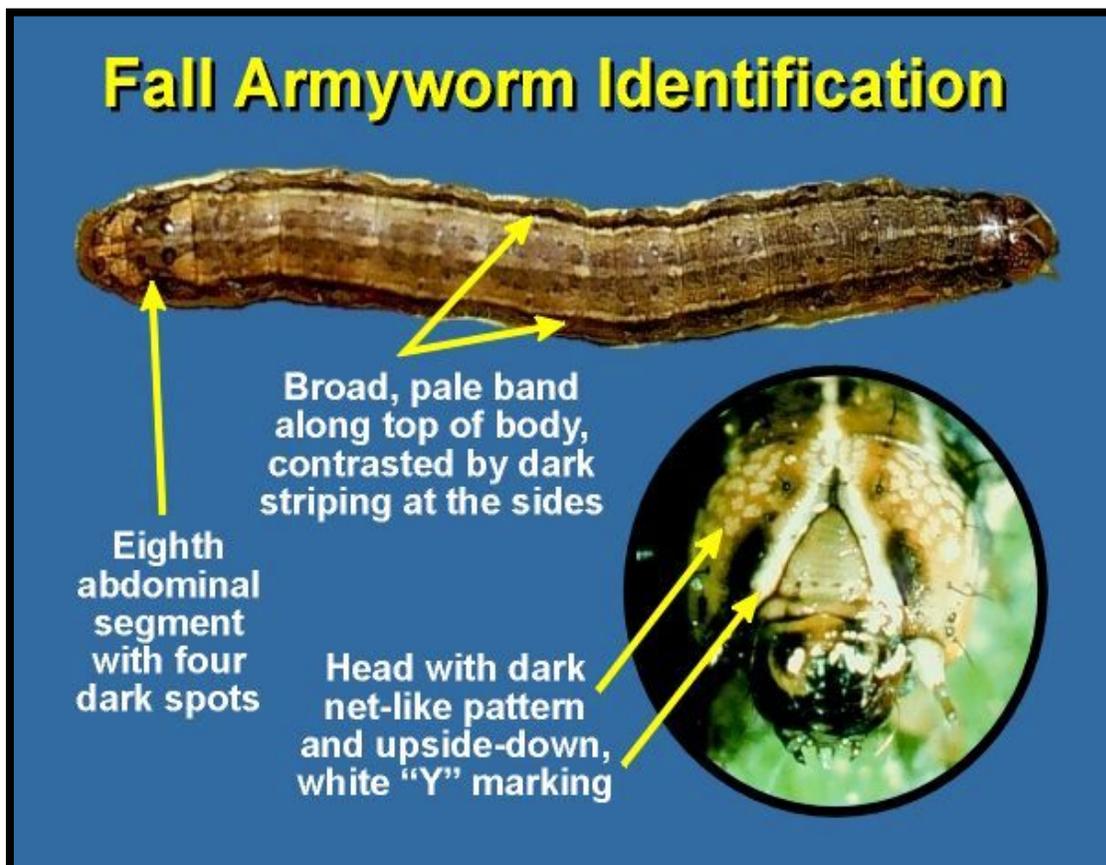


Figure 8: FAW ID info (Farmbiz Africa / University of Nebraska)

Agricultural Production Advisors should provide education on distinguishing the FAW (*Spodoptera frugiperda*) from other *Spodoptera* species, including the African armyworm (*Spodoptera exempta*), African cotton leafworm (*Spodoptera littoralis*), Cluster caterpillar (*Spodoptera litura*), Lawan armyworm (*Spodoptera mauritia*), and Beet armyworm (*Spodoptera exigua*). More recently, another newly recognized species, also introduced from South America, has been discovered in West Africa, the Southern armyworm, *Spodoptera eridania* (Stoll).

4.5 DAMAGE

FAW generally feeds on foliage, but during heavy infestations, larvae also feed on maize ears. Foliar damage to maize is usually characterized by ragged feeding, and moist sawdust-like frass (excrement produced by insects) near the whorl and upper leaves of the plant. Young larvae initially feed on one side of leaves leaving the epidermis intact on other side. Later, instars feed by making holes in leaves and eat from the edge of the leaves inward. Feeding in the whorl of maize often produces a characteristic row of perforations in the leaves.



Figure 11: Fall Armyworm damage on maize ears (CABI)



Figure 12: Fall Armyworm damage on maize ears (www.farmersreview.com)

Due to cannibalistic behavior, larval numbers are reduced to a few larvae per plant. Fully-grown larvae cause extensive defoliation, often leaving only the ribs and stalks of maize plants. Larvae can also burrow into the growing point and affect the growth of plants. In maize, larvae sometimes also bore into the ear through the husk and feed on kernels. Larvae can also cut young maize plants and kill them.

5.0 MANAGEMENT

IPM is the coordinated use of pest and environmental information and available pest control methods to economically prevent unacceptable levels of pest damage, with a focus on minimizing hazards to people, property, and the environment. IPM requires a thorough understanding of the pest, crop, and interrelationships within the environment. At the highest level, IPM requires practical research, advanced planning, balancing the costs and benefits of all control practices, as well as routine monitoring of crop and pest conditions. IPM utilizes a suite of appropriate pest management tactics, including cultural methods, mechanical control, sanitation, natural and biological control, pesticides, as well as host plant resistance. It is USAID policy to rely on an IPM framework for all activities which involve the procurement or use of pesticides. As such, it is critical to respond to clearly identified pests and their consequences, evaluate non-pesticide management options, and use the least toxic, safest pesticides and only as actually needed. As such, first develop an overall FAW management plan, then evaluate control options – including pesticides.

5.1 INTEGRATED PEST MANAGEMENT

IPM is the coordinated use of pest, crop, environmental and ecosystem information, and available pest control methods, to economically prevent unacceptable levels of pest damage, with an emphasis on minimizing hazards to people, crops, and the environment. IPM requires a good understanding of pest biology, crop vulnerability, and interrelationships within the environment. Implemented correctly, IPM can provide excellent management of a pest while minimizing pesticide exposure to farmers, their families, and the environment. IPM does require a knowledge base on pest and crop biology which has been derived from practical on-farm research, as well as planning regarding planting dates, varieties, and the option of inter-cropping. A key fundamental of IPM involves balancing the costs and benefits of all management practices compared to crop value. IPM uses regular monitoring of crop damage and pest population levels. It utilizes all suitable pest management tactics, IPM focuses on keeping pest population number below the point of causing economic damage, not completely eliminating the pest. Pest management options in the IPM “Tool Box” include pesticides, cultural methods, mechanical control, sanitation, natural and biological control, as well as host plant resistance. It is USAID policy to rely on an IPM framework for all activities which involve the procurement or use of pesticides. As such, it is critical to respond to clearly identified pests and their consequences, evaluate non-pesticide management options, and use the least toxic, safest pesticides and only as actually needed.

Economic thresholds are generally defined as the pest or disease density/damage at which the benefit derived from applying a management strategy is equal to the cost of the management strategy. Economic thresholds are variable and depend on real-world conditions and issues including the quality of available seed, fertilizer, pesticides, labor issues, water availability and quality, and the market price for a particular crop. Developing the economic threshold requires good information on local plant varieties, vulnerable growth stages, pest biology and impact on yield, field history, and effectiveness of preventive management strategies.

5.2 FAW FIELD MONITORING:

A key component IPM is monitoring pest populations. This is often done by sampling random parts of a field or, in the case of FAW, by utilizing black-light traps and pheromone traps. Pheromone traps, which specifically attract and capture adult male FAW, are very efficient and should be suspended at canopy height during the whorl stage of maize. Insect catches indicate the presence of moths in the area but may not be accurate indicators of density. Once the moths are detected through a monitoring trap or scouting – see back of each Pest Management Decision Guide (PMDG) – has a tested Scouting Form which can be used to determine treatment thresholds – see Annex 1), it is recommended to search for eggs and larvae. A random sampling of 20 plants in five locations, or ten plants in ten locations, is generally considered to be adequate to assess the proportion of plants infested. Sampling to determine larval density often requires large sample sizes, especially when larval densities are low or larvae are young, so it is not often used. It is crucial to target smaller caterpillars of a half-inch (12 mm) or less for two reasons: 1) the caterpillars do not cause severe damage until they reach a size of one inch in length; 2) smaller caterpillars are much more susceptible to insecticide and biological control than larger caterpillars. The PMDG have an excellent Scouting Form which can be used independently of the country-specific PMDG (see Annex 1 below, and this link: <https://www.agrilinks.org/post/feed-future-tools-combat-fall-armyworm-africa>).

5.3 FAW OUTBREAK

In as much as possible, farmers should follow the established preventive measures in Good Agricultural Practice (GAP), including the following actions recommended by CABI Plantwise plant clinics, FAO, and IPM Innovation Lab for preventing Fall Armyworm outbreaks:

- In as much as possible, eliminate crop residues after harvest.
- As appropriate for crop and soil conditions, deep plough the soil to bury or expose pupae.
- Reduce weeds as appropriate to crop and field.
- Apply fertilizer appropriately to ensure optimal crop growth.
- Adopt push- pull technic – plant *Desmodium* spp. in maize and sorghum fields and plant *Brachiaria* grass outside the field.
- Avoid application of broad spectrum and highly toxic chemical pesticides.
- Practice conservation biological control by protecting and preserving local natural enemies.
- Release laboratory reared parasitoids, *Telenomus remus* and *Trichogramma* spp.
- Use bio-pesticides such as *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae*, Nuclear polyhedriosis virus.
- Use botanical pesticides such as neem (*Azadirachta indica*)

5.4 CULTURAL PRACTICES:

Deep plowing can destroy the FAW pupae in soil. In addition, intercropping a corn crop with beans has shown to reduce the FAW infestations by 20-30 percent.

5.5 HOST PLANT RESISTANCE:

Transgenic maize varieties with *Bacillus thuringiensis* (BT) have been successful in controlling FAW. There are resistant varieties on the market that suppress/control FAW and other lepidopteran pests. However, FAW resistant varieties of other crops have not yet been developed.

5.5 BIOLOGICAL CONTROL:

Biological control is considered as an ecological option in an IPM approach. Among several groups of parasitoids, egg parasitoids, *Telenomus remus* (Hymenoptera: Platygasteridae) and *Trichogramma* spp (Hymenoptera: Trichogrammatidae) are deemed important and have been identified in several countries in Africa and Asia. They are easy to culture under laboratory conditions and parasitize egg masses of FAW and other lepidopteran pests. There are 11 species of *Telenomus* and 26 species of *Trichogramma*/*Trichogrammatoidea* found in Africa (Annex 4). A list of natural enemies collected on FAW in Africa and India is also provided in Annex 4.

Biological control using *Telenomus* and *Trichogramma* is effective in managing FAW when the pest is at the egg stage. However, the presence of scales/hairs over the egg masses act as a barrier against parasitism by *Trichogramma* spp. This difficulty in egg masses parasitized by *Trichogramma* species can be overcome by using a more aggressive parasitoid, one better capable of breaking the physical barrier imposed by scales on the eggs. Therefore, it is essential to know the species/strains present in the agroecosystem when choosing the *Trichogramma* species to be used for applied biological control of FAW. *Telenomus remus* has proved very effective in South America and Florida which is a new association because the wasp is native to Asia. The parasitoid *Cotesia icipe* (Hymenoptera: Braconidae) found to parasitize 33-45 percent of FAW larvae in East Africa. Another biological control agent, *Doru luteipes* (Dermoptera: Forficulidae) has been used as an agent for the biological control of FAW eggs in Brazil. In India, *Forficula* sp. (Dermoptera: Forficulidae) was found feeding on larvae of FAW.



Figure 13: Egg parasitoid *T. remus* on *Spodoptera* eggs. (Beto Peralta)



Figure 14. *T. Remus* adults (www.gebio.com.br)

Two egg parasitoids, *Telenomus remus* and *Trichogramma chilonis* are being mass reared for augmentative biological control of FAW in East Africa.

In its native regions of the Americas, FAW larvae and pupae are attacked by several species of predators and parasitoids. The wasp parasitoids most frequently reared from larvae in the U.S. are *Cotesia marginiventris* and *Chelonus texanus* (both Hymenoptera: Braconidae). In Argentina, larval parasitoids collected were *Campoletis grioti* (Hymenoptera: Ichneumonidae), *Chelonus insularis* (Hymenoptera: Braconidae), *Archytas marmoratus* (Diptera: Tachinidae) and/or *A. incertus*, *Ophion* sp. (Hymenoptera: Ichneumonidae), *Euplectrus platyhyphenae* (Hymenoptera: Eulophidae), and *Incamiya chilensis* (Diptera: Tachinidae). In Mexico, 13 genera of hymenoptera larval parasitoids belonging to three families, Braconidae, Ichneumonidae and Eulophidae were recovered. Five species of Ichneumonidae: *Diapetimorpha introit*, *Cryptus albitarsis*, *Ichneumon promissorius*, *Ichneumon ambulatorius* and *Vulgichneumon brevicinctor*, two species of Chalcididae: *Brachymeria ovata* and *B. robusta* and one Eulophid species, *Trichospilus pupivora* have also been reported on FAW pupae from U.S., Argentina and Barbados.

Although several pathogens have been shown experimentally to reduce the abundance of FAW larvae in maize, only BT is currently used, and success depends on having the product on the foliage when the larvae first appear. BT sprays tend to be short-lived as they are very susceptible to ultra-violet light degradation from normal sun shine and make require multiple sprays.

Another option for biological control of FAW is *S. frugiperda* nuclear polyhedrosis virus (NPV). A large number of isolates of NPV have been obtained from the field and some have been detected as promising isolates. Some studies have also shown that *Metarhizium anisopliae* and *Beauveria bassiana* have a potential as microbial control agents against FAW.

5.6 INSECTICIDES:

Insecticides are considered a main control option in response to FAW outbreaks. However, there are major limitations to the use of chemicals. The FAW are often inaccessible to insecticides because of their tendency to hide in the whorls of corn and reproductive parts of the host plant, limiting the efficacy of spraying.

Under developing country conditions, insecticides can be expensive and out of reach for small holder farmers. Spraying food crops with insecticides can be problematic in low income countries, as

appropriate safety procedures may not be implemented on a regular basis. Personal protective equipment may not be widely available or affordable to subsistence farmers, which increases the risk of pesticide exposure and pesticide poisoning.

Management using insecticides should be considered when substantial damage occurs on at least 25 percent of the plants. If high levels of damage are noted in isolated areas of a field, spot treatments may be warranted. For an effective control and an adequate penetration by insecticides, spraying should focus on the whorl where the larvae spends the day after feeding at night. Spraying done in the late afternoon or early evening will be more efficacious than daytime applications. Various insecticides recommended for FAW include pyrethroids, carbamates and organophosphates. Granular insecticides are also applied over the young plants because the particles fall deep into the whorl. However, a reliance on chemical control to manage pest populations has become increasingly ineffective as regional populations develop resistance to several toxicological groups of insecticides.

5.7 GENETICALLY ENGINEERED (GE) RESISTANCE TO FAW:

GE maize varieties expressing Crystal (Cry) toxins isolated from the soil bacterium BT are one of the management options used in the Americas for controlling Lepidopteran pests including the Fall Armyworm (FAW). Several BT maize varieties are available from a number of different commercial companies and have been used successfully in many countries for well over 20 years to control FAW. These include single gene products, e.g., Cry1Ab, Cry1F, as well as multigene products using BT Cry protein combinations, e.g., Cry1A and Cry2A class toxins which target different insect midgut receptors and which, together, mitigate development of pest resistance. The line-up includes both Crystal proteins and newer BT Vegetative Insecticidal Proteins, which offer an additional Mode of Action. Benefits of BT maize include effective management of target pests, decreased use of conventional insecticides, and reduced risks to non-target organisms, including humans. These BT crops have a long history of safe use and have been shown safe and efficacious by regulatory authorities around the world including the US Environmental Protection Agency, US Food and Drug Agency and US Department of Agriculture as well as the Organisation for Economic Co-operation and Development (CERA 2010, 2012, 2013; US EPA, 2001, 2007, 2010, 2011; OECD 2007).

Currently, BT maize is commercially grown in South Africa. Confined Field Trials have been conducted in Kenya, Mozambique, Tanzania, Ethiopia, and Uganda under the Water Efficient Maize for Africa (WEMA) Project. The BT events used in WEMA have been fully de-regulated in the U.S. (US EPA, 2001, 2007, 2010, 2011). USDA/FAS is working with regulatory authorities in Cambodia, Bangladesh, Burma, and India. GE maize has been approved in the Philippines, Indonesia, Vietnam, and Pakistan. Following deregulation, an additional two years for open-field evaluation of BT maize varietal trials is usually required before release (this is true also for non-GE crops), and perhaps an additional two years for seed scale-up and market saturation. However, since these requirements are country specific it is within the power of a government to expedite release for humanitarian and safety purposes. There may be additional opportunities to expedite access for BT maize in countries with less experienced or biosafety regulatory systems that have expressed openness to biotechnology: Bangladesh and Burma.

GE crops, predominantly cotton, maize and soybean, expressing BT insecticidal proteins, have been widely planted globally since 1996. GE crops are scale-neutral and most adopters both in terms of surface area and the number of farmers (up to 90% were small holder farmers) are in the developing world (ISAAA, 2016). In 2016 alone, 185 million acres, an area equivalent to the total land mass of China, was planted in GE crops. BT crops are particularly effective in controlling target insect pests while causing negligible harm to non-target beneficial biocontrol organisms. In addition, GE crops are grown with reduced chemical insecticide use. In the maize cropping system, BT proteins have become a primary tool in pest management.

5.7.1 RESISTANCE MANAGEMENT IN BT MAIZE:

Insects' development of resistance to pesticides, including BT, is a well-understood process, and technology developers go to great lengths to develop processes to prevent and mitigate resistance, especially with GE crops expressing BT toxins. Generally speaking, a common strategy is to deploy multiple toxins, with differing sites or modes of action, to delay resistance. Early GE maize varieties only expressed a single resistance gene and in rare cases resistance was selected in some insects in some geographies. Intensive use of one variety of BT maize expressing a single CryIF protein led to selection for resistance to FAW in Puerto Rico, Brazil, and the southeastern U.S. (Yang et al., 2016). Resistance to this single CryIF protein also led to cross resistance to other closely related CryI proteins. Current BT crop varieties are engineered to have multigenic/redundant (3 to 5 genes) independent modes of action. These BT varieties, notably, CryIAc/Cry2Ab, CryIAc/CryIF/Vip3A, CryIAb/Cry2Ae, or CryIAb/Cry2Ae/Vip3A, and the single-gene Cry2Ae plants, are all able to control the FAW. In some cases even CryIAc/CryIF are effective in controlling FAW, which were partially resistant to CryIF. Key to effectively controlling resistance to germplasm incorporating BT toxins is the use of an Insect Resistance Management plan, primarily built around the use of a small "refuge" -- comprised of susceptible plants on which non-resistant pest insects may develop and breed with any rarely resistant pest insects produced in the BT crop itself. These practices are variety- and crop-specific and are implemented through guidance collaboratively developed by standards-setting organizations such as Croplife, the Insecticide Resistance Action Committee and Excellence Through Stewardship.

6.0 SAFER USE ACTION PLAN

The SUAP summarizes what the conditions are for the safer use of the pesticide active ingredients (AI) recommended in this PERSUAP. Specific safety requirements are provided for each pesticide in the Table of Acceptable Pesticides (below).

At a minimum, the SUAP should contain: 1) a list of implementation team members, their duties, and overall implementation timeline; 2) a description of planned training program for farmers, agricultural extension agents, handlers, applicators; 3) a description of a plan to establish and enforce pesticide quality, use of labels or other guidance, and container standards; 4) a description of a plan to ensure that pesticide-appropriate PPE is sustainably used and supplied; a description of a plan to apply location-specific good practice methods for safe pesticide transport, storage, handling, use, and disposal, as well as safe management and disposal of empty pesticide containers.

SUAP Conditions for IPs:

- All IPs will develop a SUAP that is specific to the intervention area and IP organizations.
- Only pesticides with approved (by USEPA and host-government or a designated body where applicable) active ingredients can be procured, used or recommended for use with USAID funds.
- Pesticide products procured, used or recommended for use must be labelled in a national language and include the following essential information: 1) name and concentration of active ingredient, 2) type of formulation, 3) instructions for use, 4) user safety information, 5) safety periods for re-entry and harvest, 5) manufacturer and country of origin.
- Procure the least amount of pesticide needed to avoid storage and expiration issues.
- Basic training in safer use must be provided broadly
- Pesticides for plant protection must be part of an IPM effort
- Appropriate PPE must be available and used.
- Emphasize following label instructions, careful pesticide purchases, safe handling/storage/disposal.
- Record-keeping and resistance monitoring

- Regular reporting to USAID

SUAP Conditions for USAID staff:

- All relevant staff should work with the IP to receive appropriate training on the information requirements established by the governing PERSUAP.
- The USAID Mission must put in place effective internal procedures to review pesticide procurement requests submitted by IPs. The MEO must review and approve all procurement requests before the AOR/COR can clear.
- Use the SUAP Template below to implement a SUAP.

Project Title:					
Pesticide(s):			Crops:		
Location Common Name(s):			Target Pests:		
Required Compliance Mitigation Measures		Compliance Dates	Actions to achieve compliance	Responsible Party	Status
Capacity Building	Technical Assistance for Trainers				
	Development and Distribution of Educational Material				
	Training of Pesticide Handlers				
Local Issues	Establish Pesticide Quality Standards				
	Require Good Packaging and Clear, Adequate Labeling				
Safer Pesticide Use	Ensure Accessibility of Personal Protective Equipment				
	Define Appropriate Procedures for Safe Pesticide Transport				
	Define Appropriate Methods for Safe Pesticide Storage				
	Define Disposal Provisions for Used Pesticide Containers				
Long-Term Program	Coordination, Collaboration, Awareness raising, Surveillance, Control Management, Research				

7.0 PESTICIDE DISCUSSION / INFORMATION

Pesticides are chemical substances intended to kill, inactivate, or repel pests. The pest in this case is *S. frugiperda*, and there are a number of pesticides which can be used to control this insect. However, many chemical pesticides can also poison human beings and other life forms (including beneficial soil microbes) and contaminate the environment. When using pesticides, it is critical to be aware of the toxicological and environmental hazards associated with a particular material. Using the least toxic material makes sense in terms of human health and environmental protection. However, both active ingredients and formulations change from country to country, and often among different agricultural supply shops. Toxicity is determined not only by the active ingredient itself, but concentration, formulation, and application method as well. Note that an US EPA designation of **Restricted Use Product (RUP)** means a pesticide has the potential to cause adverse effects to the environment and injury to applicators or bystanders, and can only be used by a certified applicator. This PERSUAP therefore should be considered a guide and list of acceptable products which will need to be further defined in each affected country with an eye to safety in all aspects of pesticide use.

The list of acceptable pesticides in Section 8.0 on page 18 contains key information on each of the pesticides approved under this PERSUAP for use against the FAW in USAID sponsored projects, and should be carefully consulted prior to use. Make sure to document and keep a good record of all pesticides supported, used, and purchased by USG funds, as well as any other FAW related management decisions. In addition, all pests, including *S. frugiperda*, can develop resistance to a chemical pesticide that is used repeatedly and inappropriately. It is critical that pesticides be alternated to minimize the occurrence of pesticide resistance. If there is a pesticides which fits the §216.3(b)(l) criteria (last paragraph below) it can be added by amending this PERSUAP – contact Bill Thomas (withomas@usaid.gov) and John Bowman (jobowman@usaid.gov) at BFS to discuss.

Other critical elements regarding the use of chemical pesticides include: 1) Training those who will handle and apply pesticides; 2) Use and care for appropriate and available PPE; 3) Appropriate storage of pesticides and empty pesticide containers; 4) Safe disposal of unused pesticide and empty pesticide containers; 5) Environmental precautions.

Insecticide resistance in FAW was first noted in 1979 when a population of FAW collected from a maize field in Tifton, Georgia (U.S.) was shown to be resistant to carbaryl. A strain of FAW collected from maize in northern Florida (U.S.) showed resistance to commonly used insecticides in 1991. It has also shown some resistance to current chemical pesticides, limiting the effects of a carbamates, organophosphates and pyrethroid group of insecticides.

Any expenditure of USAID funds which involve the use of pesticides (purchase, recommendation, training, or other related support) shall evaluate each pesticide according to the procedures described in §216.3(b)(l): (a) The USEPA registration status of the requested pesticide; (b) The basis for selection of the requested pesticide; (c) The extent to which the proposed pesticide use is part of an integrated pest management program; (d) The proposed method or methods of application, including availability of appropriate application and safety equipment; (e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use and measures available to minimize such hazards; (f) The effectiveness of the requested pesticide for the proposed use; (g) Compatibility of the proposed pesticide with target and non-target ecosystems; (h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils; (i) The availability and effectiveness of other pesticides or nonchemical control methods; (j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide; (k) The provisions made for training of users and applicators; and (l) The provisions made for monitoring the use and effectiveness of the pesticide.

8.0 TABLE OF ACCEPTABLE PESTICIDES (LISTED IN ASCENDING ORDER, FROM LEAST TOXIC TO MORE TOXIC TO HUMANS)

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
<i>Bacillus thuringiensis (BT) var. kurstaki</i>	Thuricide	EPA: III Caution WHO: Not acute hazard	0	Practically non-toxic, could cause moderate eye irritation	Selective for caterpillars only, not toxic to other organisms	<i>BT</i> is a bacterium selectively toxic to many moth and butterfly larvae (caterpillars). Insects stop feeding and die within 2-3 days of ingestion. This product may be applied up to the day of harvest. Most countries require specific registration of strains.	Low	Low
<i>Beauveria bassiana</i>	Depends on strain	EPA: III Caution WHO: Not acute hazard	0	Causes moderate eye irritation. Harmful if absorbed through the skin, inhaled or swallowed. May produce an allergic reaction. No expected long-term risks.	May be toxic to bees, fish and aquatic organisms. Potentially pathogenic to honey bees.	<i>Beauveria bassiana</i> is a naturally occurring fungal insecticide that is commonly found in soils worldwide and is used as a pesticide for controlling many kinds of insects. Also registered for use on potatoes, peppers, and eggplants, ornamentals, fruits, turf.	Low	Low
<i>Metarrhizium anisopliae</i>	Depends on strain	EPA: III Caution WHO: Not acute hazard	0	Harmful if swallowed, inhaled or absorbed through skin. Causes moderate eye irritation. No expected long-term risks.	No major threats to non-target organisms, Potential water contaminant	Also registered for use on potatoes, peppers, and eggplants. <i>Metarrhizium anisopliae</i> is a natural biopesticide based on the naturally occurring fungus. It is effective against a variety of pests. It should be applied when the temperature is between 18-28°C/65-82°F and the relative humidity is approximately 80%.	Low	Low

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
SfM nuclear polyhedrosis virus (NPV) Spodoptera frugiperda Multiple Nucleopolyhedrovirus strain 3AP2 (129346)	Fawligen	EPA: IV Caution WHO: N/A	0	May cause skin sensitization in susceptible individuals; Repeated exposure may cause an allergic response	None detected	Baculoviruses are ubiquitous in the environment. They are species specific narrow spectrum insecticidal applications. No impacts on non-target insects, plants, mammals, birds, or fish. Can be used as part of an overall IPM program	Low	Low
Azadirachtin	Neem	EPA: III Caution WHO: Not listed	0	potential endocrine disruptor with significant contact	Slightly toxic to fish, may be hazardous to some aquatic invertebrates	Can often be produced locally as the tree is wide spread. It has been used as an antifeedant and growth disruptor.	Low	Low
methoxyfenozide	Intrepid	EPA: III Caution WHO: Not acute hazard	21	Harmful if absorbed through skin. Avoid contact with eyes and skin or clothing. Avoid breathing spray mist. Target organ toxicity. May impair the blood's ability to transport oxygen	May be hazardous to aquatic invertebrates.	It belongs to the diacylhydrazine class and mimics the action of molting hormone of lepidopteran insects. It is an ecdysone agonist, causing cessation of feeding and lethal premature molt. complete mortality of insect may take several days but the affected larvae becomes lethargic. It does not have any systemic properties.	Low/Medium	Low/Medium
chlorantraniliprole	Coragen	EPA: III Caution WHO: Not acute hazard	21	Mild/transient eye irritation	Toxic to aquatic invertebrates, oysters and shrimp. Potential groundwater contaminant	Also registered for use on cotton, citrus, ornamentals and vegetables. It acts primarily through ingestion and also through contact. Affected insects rapidly stop feeding, general lethargy, paralysis and ultimate death.	Low	Medium

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
spinetoram	Delegate	EPA: III Caution WHO: Not acute hazard	1	Can cause moderate eye irritation Avoid contact with eyes or clothing. Suspected developmental toxin.	Toxic to bees exposed to treatment during the 3 hours following treatment. Toxic to aquatic invertebrates.	Also registered for use on cotton, citrus, ornamentals and vegetables. Fermentation product of <i>Saccharopolyspora spinosa</i> . Acts as contact and stomach poison and causes paralysis. Analogue of spinosad, a spinosyn]	Low/Medium	Medium
spinosad	Success	EPA: III Caution WHO: Not acute hazard	1	May cause from slight eyes irritation	Slightly toxic to earthworms; Moderately toxic to fish; Highly toxic to bees.	Spinosad is toxicologically identical to spinetoram (see entry above)	Low/Medium	Medium
imidacloprid	Admire Pro Many ag use products are RUP . Primarily used only for turf grass in US. Also an ingredient mixed with other AIs, but those mixtures are RUP . Status of imidacloprid containing product restrictions will depend on type of intended use.	EPA: III Caution WHO: Not acute hazard	0	Harmful if swallowed or absorbed through skin. Suspected dev/reproductive toxin	Not acutely toxic to fish; Extremely toxic to insects, and honeybees, expressed in pollen and nectar; was suspect in causing pollinator colony collapses	Systemic insecticide with translaminar activity and with stomach and contact action. It can be applied as soil, seed and foliar treatment for the control of sucking insects as well as soil insects. Avoid flowering crops in bloom.	Low/medium	Medium

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
spinoteram + methoxyfenozide	Intrepid Edge GF-3028; GF-2986	EPA III Caution WHO: N/A	1	Moderate eye irritation, possible skin irritation with prolonged use. Spineteram is a potential developmental toxin	Toxic to aquatic invertebrates, toxic to bees. Chemical properties indicate potential for groundwater pollution.	Used for nuts, fruits, vegetables. See listings for individual ingredients.	Medium	Medium
acetamiprid	Gazelle	EPA: III Caution WHO: Not acute hazard	7	Harmful if swallowed. inhaled or absorbed through skin. Causes moderate eye irritation. Not likely a carcinogen.	Extremely toxic to fish and aquatic invertebrates. highly toxic to bees	Systemic insecticide with translaminar activity and with contact and stomach action. Neonicotinoid.	Medium	Medium
dimethoate	Dimethoate Only one product listed as RUP is Arysta 4E.	EPA: Warning WHO: Moderately hazardous	15	Moderate to severe skin irritation. Severe irritation of eyes.	Slightly toxic to fish, HT to amphibians and crustaceans and highly toxic to bees	Systemic insecticide and acaricide with contact and stomach action. It is a cholinesterase inhibitor.	Medium	Medium
indoxacarb + acetamiprid	No agricultural crop protection products registered in the US Registered only for ornamentals and structures in the US.	EPA: III Caution WHO: Not acute hazard	21	It may cause mild eye irritation with tearing, & blurred vision. May cause skin sensitization with allergic rashes.	Moderately toxic to bees, Highly toxic to fish and crustaceans.	Indoxacarb is a contact poison. Affected insects stop feeding with poor coordination and paralysis and ultimate death. Effective against lepidopteran pests of cotton, vegetable and fruits, but only registered in US for ornamentals and facilities. Acetamiprid is a neonicotinoid (see entry)	Medium	Medium

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
thiamethoxam		EPA: II/III Warning/Caution WHO: Not listed	21	Can cause moderate eye and skin irritation. Medium target organ toxicity; WHO recently identified potential for developmental toxicity.	Products can be highly toxic to aquatic organisms and bees. Should not be used where groundwater is shallow, can contaminate groundwater	Many, but not all products are intended for use of seed and seedling treatment;	Medium	Medium
azadirachtin	AzaGuard	EPA: III Caution WHO: N/A	1	Skin and eye irritant, may cause an allergic reaction, harmful if inhaled	Can be very toxic to aquatic organisms and to bees	This information pertains only to commercial products	Medium	Medium /High
flubendiamide	No products registered in the US Belt SC is no longer registered by USEPA	EPA: III Caution WHO: III	28	Harmful if absorbed through skin, Causes moderate eye irritation.	Toxic to aquatic invertebrates	Flubendiamide is a broad spectrum lepidopteran insecticide. There are no products containing this AI registered in the US, due to cancellation based on aquatic toxicity	Low/Medium	Medium /High
malathion	Malathion	EPA: II Warning WHO: Slightly hazardous	7	Harmful if swallowed or absorbed through skin. Causes substantial but temporary eye injury. Suspected neurotoxicant	Toxic to aquatic organisms, including fish / invertebrates. Highly toxic to bees. Do not apply or allow drift into blooming crops if bees present in or near treatment area.	Non-systemic insecticide and acaricide with contact and stomach and respiratory action. Used on potatoes, vegetables, cotton and rice.	Low/Medium	Medium /High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
abamectin	Abba is RUP , due to aquatic toxicity Most products that are over 1.8% are RUP due to aquatic toxicity.	EPA: Warning WHO: Moderately Hazardous	28	May cause slight to moderate eye and skin irritation. Not readily absorbed through the skin. Reproductive toxin and endocrine disruptor.	Highly toxic to crustaceans and bees. Low toxicity to fish	Abamectin is a natural fermentation product of a soil bacterium <i>Streptomyces avermitilis</i> . It is an Insecticide/miticide/acaricide with stomach and contact mode of action. It is used to control insect and mite pests of a range of agronomic, fruit, vegetable and ornamental crops.	Medium	Medium High
emamectin benzoate	Proclaim is RUP Products containing this AI in concentration over 1.8% are all RUP	EPA: Caution WHO: Not acute hazard	7	Proclaim is low acute and medium chronic human toxicity Harmful if swallowed, inhaled, or absorbed through skin. Causes moderate eye irritation.	Toxic to fish, birds, mammals, and aquatic invertebrates	Controls the larval stages of certain lepidopteran species, has contact activity but is most efficacious when ingested.	Medium	Medium High
acetamiprid + lambda-cyhalothrin	No such products in the US Such combination in all formulations most likely to be RUP for aquatic toxicity.	EPA: Warning WHO: N/A	21	May cause slight irritation of the eye and skin. Could cause gastrointestinal disorders if swallowed.	Highly toxic to aquatic organisms and pollinators.	Lambda-cyhalothrin products are RUP and therefore combination is a RUP. Acetamiprid is a neonicotinoid (see entry)	Medium	High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
bifenthrin	Capture is RUP Most or all bifenthrin containing products are RUP for aquatic toxicity	EPA: Warning WHO: Moderately hazardous	30	Fatal if swallowed. Harmful if inhaled or absorbed through skin. Causes moderate eye irritation. Possibly carcinogenic and reproductive toxin	Extremely toxic to fish and aquatic invertebrates. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use on cotton, citrus, ornamentals and vegetables. It is a member of the pyrethroid class with contact and stomach action. It acts on the nervous system of insects, disturbs the function of neuron by interaction with sodium channels.	Medium	High
carbaryl	Sevin	EPA: Warning WHO: Moderately hazardous	48	Harmful if swallowed, inhaled or absorbed through skin. Overexposure can result in convulsions, coma, and death. Likely to be carcinogenic in humans.	Extremely toxic to estuarine and aquatic invertebrates, highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use on cotton, citrus, ornamentals and vegetables. It is a member of the carbamate class with contact and stomach action and slight systemic properties.	Medium /High	Medium /High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
chlorantraniliprole + lambda-cyhalothrin	Besiege is RUP All US products for ag uses containing lambda-cyhalothrin registered in the US are likely to be RUP .	EPA: Caution WHO: N/A	21	Fatal if swallowed. Harmful if absorbed through skin. Causes moderate eye irritation, may cause allergic skin reactions. Possible carcinogen.	Extremely toxic to fish, aquatic invertebrates and wildlife. Highly toxic to bees. Do not apply this product or allow drifting to blooming crops if bees are visiting the treatment area.	Also registered for use on canola, vegetables. cereal crops. Broad-spectrum insecticide providing both rapid knockdown and long-lasting residual control of lepidopteran, sucking and chewing insect pests. It has dual modes of action and provides control by contact, ingestion and ovicidal action.	Medium	High
chlorpyrifos	Dursban is RUP Almost or all agricultural use products registered in the US are likely RUP .	EPA: Warning WHO: Moderately hazardous	5	Fatal if swallowed. Harmful if absorbed through skin. May cause developmental delays in children exposed to it in drinking water or in farming communities, potential cholinesterase inhibitor	Toxic to fish, aquatic organisms, small mammals and birds. Highly toxic to bees. Do not apply this product or allow drifting to blooming crops if bees are visiting the treatment area.	1% granular baits that are not RUP are registered only for decorative and lawn care	Medium	High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
<i>gamma</i> -cyhalothrin	Proaxis is RUP Almost or all agricultural use products registered in the US are likely RUP Non-RUP registered for ornamental use and treatment of food storage facilities.	EPA: Warning WHO: Moderately Hazardous	21	Harmful if swallowed, inhaled or absorbed through skin. Causes moderate eye irritation. Possible carcinogen, possible endocrine disruptor.	Extremely toxic to fish and aquatic invertebrates and wildlife. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use on some row crops and vegetables, but all are RUP in US. Non-RUP only permitted for ornamental use and treatment of food storage facilities. It is a non-systemic insecticide with contact and stomach mode of action. It acts on the nervous system of insects, disturbs the function of neuron by interaction with sodium channels.	Medium	High
<i>lambda</i> -cyhalothrin	Warrior II is RUP Karate is RUP Karate with Zeon technology is RUP Almost or all agricultural use products registered in the US are likely RUP .	EPA: Caution WHO: Not acute hazard	21	Fatal if swallowed. Aspirational hazard. Harmful if absorbed through skin. Causes moderate eye irritation. Possible carcinogen.	Extremely toxic to fish and aquatic invertebrates and wildlife. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use cotton, ornamentals and some vegetables, but mostly tree crops. Use on field crops is largely RUP. It is a non-systemic insecticide with contact and stomach mode of action and repellent properties. It acts on the nervous system of insects, disturbs the function of neuron by interaction with sodium channels. it gives rapid knock down and has long residual activity.	High Products that are encapsulated (Zeon) are low human toxicity	High High
thiamethoxam + <i>lambda</i> -cyhalothrin	Endigo ZC/ ZCX, Eforia RUP Ag use products containing Lambda-cyhalothrin are usually all RUP	EPA: II Warning WHO: N/A	21	Potential skin irritant, may cause cancer, may cause damage to organs through prolonged or repeated exposure	Products can be highly toxic to aquatic organisms and bees. Should not be used where groundwater is shallow, can contaminate groundwater		Medium	High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
cypermethrin- <i>beta</i>	Respect is RUP Ammo is RUP ; Cymbush is RUP Cypermethrin agricultural products have been removed from the market. Beta- and alpha- stereochemistry have some agricultural uses but are RUP .	EPA: Caution WHO: Not acute hazard	30	Harmful if swallowed, inhaled or absorbed through skin. Causes moderate eye irritation. Avoid contact with eyes and breathing spray mist. A possible carcinogen and suspected endocrine disruptor.	Toxic to aquatic invertebrates, oysters and shrimp. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Used primarily for livestock and ectoparasite and household pests. Also registered for use on cotton, citrus, ornamentals and cole crops, but are RUP for these uses.	Medium	High
deltamethrin	Decis Forte is RUP Deltagard is RUP Most products registered for agricultural use are RUP, particularly when they are EC formulation. Most products registered for ornamental, storage, and household use only.	EPA: Warning WHO: Moderately Hazardous	21	Harmful if swallowed, causes moderate eye irritation	Extremely toxic to fresh water and estuarine fish and invertebrates; highly toxic to bees exposed to direct treatment on blooming crops or weeds.	Pyrethroid that can be applied only onto fields where a vegetative buffer strip of at least 10 feet exists between the field and down gradient aquatic habitat.	Medium	High

Active ingredient	Example of trade name products	Toxicity EPA, WHO	Pre-Harvest Interval (days)	Acute/Chronic Toxicity (human hazards)	Eco-toxicity	Other Comments/Crops	Human toxicity ranking	Enviro toxicity ranking
permethrin	Ambush is RUP Limited number of agricultural products are registered in the US (products registered for ornamental, storage, and household use.)	EPA: III Caution WHO: Moderately hazardous	30	Harmful if swallowed, inhaled or absorbed through skin. Causes skin irritation. Possible carcinogen. Avoid contact with eyes and breathing spray mist	Extremely toxic to fish and aquatic invertebrates. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use on cotton, citrus, ornamentals and vegetables. It is a non-systemic insecticide with contact and stomach action and some repellent properties. It acts on the nervous system of insects, disturbs the function of neuron by interaction with sodium channels	Medium	High
<i>beta</i> -cyfluthrin	Baythroid RUP Bulldock RUP Almost all or all products registered in the US are RUP . Only a few non-RUPs and they are only for ornamental use only.	EPA: Warning WHO: Moderately Hazardous	21	Harmful if swallowed, inhaled or absorbed through skin. Causes substantial but temporary eye injury. Possible carcinogen.	Extremely toxic to fish and aquatic invertebrates. Highly toxic to bees. Do not apply this product or allow to drift to blooming crops if bees are visiting the treatment area.	Also registered for use on cotton, citrus, ornamentals and vegetables. It is a non-systemic insecticide with contact and stomach action. it causes rapid knock down and has long residual activity. It acts on the nervous system of insects, disturbs the function of neuron by interaction with sodium channels.	Medium /High	High

9.0 ANNEXES

ANNEX I

COUNTRY-SPECIFIC PEST MANAGEMENT DECISION GUIDE / SCOUTING FORM

EXAMPLE ON NEXT TWO PAGES: KENYA PEST MANAGEMENT DECISION GUIDE AND SCOUTING FORM
LINKS TO ADDITIONAL PMDG FOR FAW ON MAIZE

Kenya PMDG  Kenya PMDG 1.12 MB	Mozambique PMDG  Mozambique PMDG 1.12 MB	Tanzania PMDG  Tanzania PMDG 1.12 MB
Liberia PMDG  Liberia PMDG 1.12 MB	Rwanda PMDG  Rwanda PMDG 1.12 MB	Uganda PMDG  Uganda PMDG 1.12 MB
Malawi PMDG  Malawi PMDG 1.12 MB	Senegal PMDG  Senegal PMDG 1.12 MB	Zambia PMDG  Zambia PMDG 1.12 MB
Mali PMDG  Mali PMDG 1.17 MB		

Fall Armyworm (FAW) on Maize

Kenya

Spodoptera frugiperda

	Prevention	Scouting	Direct control	Direct control	Restrictions	
 <p>Fall Armyworm egg mass (Desiree van Heerden, Syngenta)</p>	<ul style="list-style-type: none"> Plant early, with the first rains, as Fall Armyworm (FAW) populations build up later in the crop season. Avoid planting at different times as this provides a continuous source of food for FAW. If available, plant maize varieties with resistance to FAW. Consider planting maize varieties with short maturity periods. Ensure optimum use of fertilizer for healthy and vigorous maize plants, so that they can compensate for pest damage. Keep the area around the plot free of weedy grasses. Plant hedgerows of leguminous trees or perennial flowering plants around the fields, to the extent possible, to provide shelter to beneficial insects, predators and birds. Intercrop maize with compatible and less susceptible crops, such as beans and cassava. 	<ul style="list-style-type: none"> Start scouting as soon as maize seedlings emerge. Scout 10-20 consecutive plants in 5 different locations in the field and calculate % of infestation (See Scouting Form). Look for signs of FAW feeding: <ul style="list-style-type: none"> FAW are easiest to control when the larvae are very small. FAW larvae are extremely hard to find when they are small. Look for FAW feeding signs in the central emerging leaves (whorl): light coloured patches ("window panes") and elongated holes. Look for accumulation of FAW excreta in the whorl. <p>Decision point:</p> <ul style="list-style-type: none"> At early whorl stage (knee high), take action if >20% of plants are damaged. At late whorl stage (shoulder high), take action if >40% of whorls are freshly damaged. At tassel and silk stage, do not spray pesticides. 	<p><i>This Green Column describes control options that are safest for smallholder farmers.</i></p> <ul style="list-style-type: none"> On small-scale farms, handpick and destroy the egg masses and larvae. 	<p><i>This Yellow Column describes control options that require additional safety precautions for smallholder farmers.</i></p> <ul style="list-style-type: none"> Avoid spraying broad spectrum synthetic insecticides which might kill beneficial insects or harm the applicator. Only select products with proven success in controlling FAW, such as those listed below. Personal Protective Equipment (PPE) must be worn to minimize exposure to insecticides. PPE includes coveralls, gloves, respirators and boots. The Pre-Harvest Interval (PHI) is the time between the application of a pesticide and when that crop can be harvested. The PHI values below were determined with a precautionary approach, but if the PHI value on the pesticide label is higher, observe the longer period. The Restricted Entry Interval (REI) is the period of time after spraying before anyone should re-enter the field. The REI values provided apply to situations in which PPE is not available. If the REI printed on the pesticide label is longer than the value given below, please observe the longer period. <p>For more information, please consult: Fall Armyworm in Africa: A Guide for Integrated Pest Management (USAID & CIMMYT), WHO Recommended Classification of Pesticides (WHO), Pesticide Risk Assessment (Jepson et al., DOI: 10.1098/rstb.2013.0491)</p>		
 <p>Fall Armyworm caterpillar. Look for the inverted "Y" on the head or the cluster of four dots on the rear (Russ Ottens, University of Georgia, Bugwood.org)</p>						
 <p>Damage to leaf, resulting in a "window pane" (Phil Sloderbeck, Kansas State University, Department of Entomology)</p>						
<ul style="list-style-type: none"> <i>Bacillus thuringiensis</i> 						<ul style="list-style-type: none"> REI 1 day; PHI 1 day WHO Class III Slightly Hazardous
<ul style="list-style-type: none"> Spinosad 						<ul style="list-style-type: none"> REI 1 day; PHI 3 days WHO class III Slightly Hazardous
<ul style="list-style-type: none"> Chlorantraniliprole 	<ul style="list-style-type: none"> REI 1 day; PHI 21 days WHO Class U Unlikely Acute Hazard 					
<ul style="list-style-type: none"> Indoxacarb 	<ul style="list-style-type: none"> REI 1 day; PHI 21 days WHO class II Moderately Hazardous 					
<ul style="list-style-type: none"> Alpha-cypermethrin 	<ul style="list-style-type: none"> REI 1 day; PHI 21 days WHO class II Moderately Hazardous 					

Scouting Form

Planting Date:	District:	Location:	Your name:																		
	Week 1	Week 2	Week 3																		
Sampling Date																					
Maize Growth Stage:																					
Dates of rainfall /intensity:																					
Insecticides Applied/Rates/Dates:																					
Pheromone Trap Data	Raise the trap as the maize grows taller. Keep the bottom of the trap 30 cm above the plants.																				
Number of FAW moths:																					
Number of AAW moths:																					
Early Whorl Stage (VE-V6)	Examine two to three (2-3) newest leaves emerging from the whorl.																				
Five Stops	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%
#Plants with fresh window panes/ Total																					
#Plants with infested whorls/ Total																					
Late Whorl Stage (V7-VT)	Examine three to four (3-4) newest leaves emerging from the whorl plus the emerging tassel.																				
Five Stops	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%
#Plants with fresh window panes/ Total																					
#Plants with infested whorls/ Total																					
Tassel & Silk Stage (R1-R3)	Examine ear(s) plus leaves and leaf axils at, above, and below the ears.																				
Five Stops	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%	1	2	3	4	5	Sum	%
#Plants with any fresh damage/ Total																					
#Plants with worms/ Total																					
#Plants with damaged ear/cob/ Total																					

ANNEX 2.

BIOLOGICAL CONTROL AGENTS: PARASITOID WASPS OF FALL ARMYWORM EGGS.

ANNEX 2. TABLE 1: LIST OF TELENOMUS SPP.

Telenomus spp.	Host
<i>T. procas</i>	<i>Antigastra catalaunalis</i>
<i>T. nemesis</i>	<i>Chilo orichalcociliellus</i>
<i>T. busseolae</i>	<i>Busseola fusca</i> , <i>Sesamia</i> spp., <i>Coneista ignefusalis</i>
<i>T. creusa</i>	<i>Chilo diffusilineus</i>
<i>T. bini</i>	<i>Maliarpha separratella</i> , <i>Chilo</i> spp., <i>Scirpophaga</i> spp.
<i>T. thestor</i>	<i>Chilo orichalcociliellus</i>
<i>T. sudanensis</i> ,	<i>Chilo zacconius</i>
<i>T. nephele</i>	<i>Scirpophaga melanoclista</i> , <i>S. occidentella</i> , <i>S. subumbrosa</i>
<i>T. etielliphaga</i>	<i>Etiella zinckenella</i> ,
<i>T. applanatus</i>	<i>Eldana saccharina</i>
<i>T. versicolor</i>	<i>Scirpophaga melanoclista</i>

ANNEX 2. TABLE 2. TRICHOGRAMMATIDAE EGG PARASITOIDS

Trichogrammatidae	Host
<i>Trichogramma bourarachae</i>	<i>Helicoverpa armigera</i>
<i>Trichogramma bournieri</i>	<i>Chilo partellus</i>
<i>Trichogramma cacoeceiae</i>	-
<i>Trichogramma chilonis</i>	<i>Eldana saccharina</i> , <i>Busseola fusca</i> , <i>C. partellus</i>
<i>Trichogramma ethiopicum</i>	-
<i>Trichogramma evanescens</i>	<i>Chilo Agamemnon</i> , <i>Helicoverpa armigera</i> , <i>Pectinophora gossypiella</i> , <i>Spodoptera littoralis</i>
<i>Trichogramma japonicum</i>	<i>Chilo partellus</i>
<i>Trichogramma kalkae</i>	<i>Diopsis macrophthalma</i>
<i>Trichogramma</i> sp. nr <i>kalkae</i>	-
<i>Trichogramma kayo</i>	-
<i>Trichogramma mandelai</i>	<i>Diparopsis watersi</i>
<i>Trichogramma</i> sp. nr <i>mwanzai</i>	<i>Chilo diffusilineus</i> , <i>Chilo partellus</i> , <i>Busseola fusca</i> , <i>Eldana saccharina</i> , <i>Sitotroga cerealella</i>
<i>Trichogramma ostriniae</i>	<i>Busseola fusca</i> , <i>Chilo partellus</i>
<i>Trichogramma papilionidis</i>	
<i>T. Pretiosum</i>	Apple leaf roller
<i>Trichogramma pinneyi</i>	<i>Diopsis macrophthalma</i>
<i>Trichogramma</i> sp. nr <i>exiguum</i>	<i>Chilo partellus</i>
<i>Trichogramma voegel</i>	-
<i>Trichogrammatoidea armigera</i>	<i>H. armigera</i>
<i>Trichogrammatoidea bactrae</i>	<i>P. gossypiella</i>
<i>Trichogrammatoidea citri</i>	-
<i>Trichogrammatoidea combreti</i>	-
<i>Trichogrammatoidea cryptophlebia</i>	<i>Cryptophlebia batrochopa</i> , <i>C. leucotreta</i>
<i>Trichogrammatoidea eldanae</i>	<i>E. saccharina</i> , <i>Sesamia calamistis</i>
<i>Trichogrammatoidea lutea</i>	<i>C. partellus</i> , <i>B. fusca</i> , <i>H. armigera</i> , <i>H. armigera</i>
<i>Trichogrammatoidea simmondsi</i>	<i>Diopsis macrophthalma</i> , <i>C. partellus</i> , False codling moth, <i>H. armigera</i> , <i>Atherigona soccata</i>

ANNEX 2. TABLE 3 FAW NATURAL ENEMIES

INDIA

<i>Telenomus</i> sp.	Hym.: Platygasteridae	Egg parasitoid
<i>Trichogramma</i> sp.	Hym. : Trichogrammatidae	Egg parasitoid
<i>Glyptapanteles creatonoti</i>	Hym.: Braconidae	Larval parasitoid
<i>Campoletis chlorideae</i>	Hym.: Ichneumonidae	Larval parasitoid
Ichneumonid sp.	Hym.: Ichneumonidae	Larval-pupal parasitoid
<i>Forficula</i> sp.	Dermaptera: Forficulidae	Larval predator
<i>Metarhizium</i> (<i>Nomuraea</i>) <i>rileyi</i>	Fungus	Affects larvae

EAST AFRICA

<i>Telenomus remus</i>	Hym.: Platygasteridae	Egg parasitoid	Kenya, Ethiopia
<i>Trichogramma chilonis</i>	Hym. : Trichogrammatidae	Egg parasitoid	Kenya, Ethiopia
<i>Chelonus curvimaculatus</i>	Hym.: Braconidae	Egg-larval parasitoid	Kenya
<i>Cotesia icipe</i>	Hym.: Braconidae	Larval parasitoid	Kenya, Ethiopia
<i>Coccygidium luteum</i>	Hym.: Braconidae	Larval parasitoid	Kenya, Ethiopia, Tanzania
<i>Palexorista zonata</i>	Dip.: Tachinidae	Larval parasitoid	Kenya, Ethiopia
<i>Charops alter</i>	Hym.: Ichneumonidae	Larval parasitoid	Kenya, Tanzania

NIGER

<i>Trichogramma</i> sp.	Hym. : Trichogrammatidae	Egg parasitoid
<i>Trichogrammatoidea armigera</i>	Hym. : Trichogrammatidae	Egg parasitoid
<i>Telenomus remus</i>	Hym.: Platygasteridae	Egg parasitoid
<i>Chelonus</i> sp.	Hym.: Braconidae	Egg-larval parasitoid
<i>Cotesia</i> sp	Hym.: Braconidae	Larval parasitoid
<i>Charops</i> sp.	Hym.: Ichneumonidae	Larval parasitoid
Ichneumonid sp.	Hym.: Ichneumonidae	Larval parasitoid
Tachinid sp.	Dip.: Tachinidae	Larval parasitoid

Annex 4 Cereal Systems Initiative for South Asia Fall Armyworm Infographics

The **International Maize and Wheat Improvement Center** (CIMMYT) and **Cereal Systems Initiative for South Asia** (CSISA) recently (May 2019) put out a series of excellent and highly recommended **Infographics on the Fall Armyworm**.

Four examples follow this page. These Infographics can also be accessed on-line:

- Fall Armyworm Life Cycle
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-FAW_life_cycle_final-NXPowerLite-Copy.pdf
- What is Fall Armyworm and why is it a threat?
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-FAW_overview_final-NXPowerLite-Copy.pdf
- What is the Fall Armyworm and how can I scout for it in my field?
 - i. <https://csisa.org/wp-content/uploads/sites/2/2019/05/190512-PostCard-3-FAW-Surveillance-NXPowerLite-Copy.pdf>
- What should I do if I find Fall Armyworm damage?
 - i. https://csisa.org/wp-content/uploads/sites/2/2019/05/190512_FAW_control_final.pdf

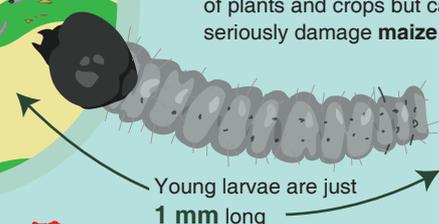
What should I do if I find Fall Armyworm damage?



Fall Armyworm is a pest that feeds on

80 types

of plants and crops but can seriously damage **maize**.

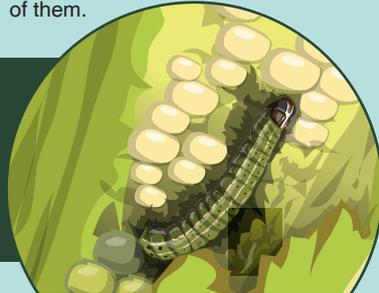


Young larvae are just **1 mm** long

Scientists have found Fall Armyworm in **South Asia** and expect this pest will damage farmers!



There are many ways you can control Fall Armyworm. Let's learn about some of them.



After you have scouted for and found sufficient Fall Armyworm damage, how can you control it?



Mechanical Control

Scout your field and crush Fall Armyworm eggs and young larvae. This will reduce the pest population but not completely control Fall Armyworm.



Worm eggs

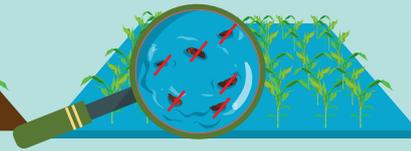
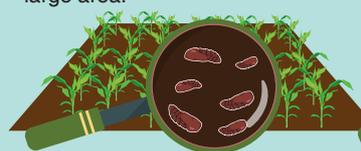


Young larva



Pupae

If you have access to irrigation, flooding with a few centimeters of water can reduce Fall Armyworm numbers by drowning pupae. This method works best when many farmers irrigate at a similar time to reduce populations over a large area.



Use smart agronomy

- Avoid planting your field late.



Late planting

- Plant your field early.



Early planting

- Use intercropping and increase the diversity of crops on and around your field.



- Manually weed your field. This will kill pupae and reduce populations in a similar way as irrigation.



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Biologically-based insecticides

- Biologically-based insecticides include Bt, and Baculovirus-based biopesticides. *Spodoptera frugiperda* multiple nucleopolyherovirus is also effective and has a low-risk of killing beneficial insects. It makes Fall Armyworm sick and die.



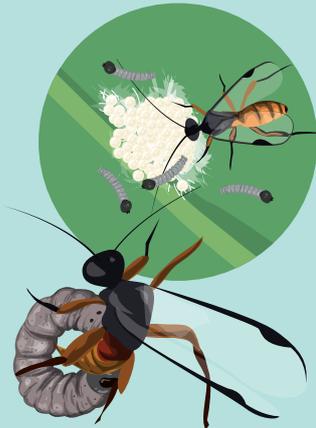
- Before spraying pesticides, let spiders, ants and parasitic insects work for you! Spiders and some wasps can kill Fall Armyworm. These insects are farmers' friends and will kill Fall Armyworm for you.



- Encourage parasitoids that will lay eggs in Fall Armyworm egg masses and also in their larvae. When eggs hatch, they kill Fall Armyworm.



- Spiders, ants, and many other insects will eat eggs and larvae of this pest.



Chemical control

Important!



You should **only use chemical control** if you have properly scouted your field, identified Fall Armyworm damage, and consulted with an extension agent or qualified advisor. Insecticides should only be applied by a trained professional.



Spraying before you have scouted and identified or Fall Armyworm in your field is expensive and unlikely to be effective.



Never spray pesticides when it is windy or when people or children are near your field.



Insecticides are a last resort to use after you try mechanical, agronomic, and biological control methods.



Store insecticides in a locked box outside your home. Keep insecticides out of the reach of children.

The Cereal Systems Initiative for South Asia (CSISA) was established in 2009. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). The content and opinions in this infographic do not necessarily reflect the views of the Bill and Melinda Gates Foundation, USAID, or the United States Government, and shall not be used for advertising or product endorsement purposes. Correct citation: Krupnik, T.J. and Dhungana, H. 2019. Krupnik, T.J. and Dhungana, H. 2019. What should I do if I find Fall Armyworm damage? International Maize and Wheat Improvement Center. Dhaka, Bangladesh.

International Maize and Wheat Improvement Center (CIMMYT).
Office: House 10/B. Road 53. Gulshan-2. Dhaka, 1213, Bangladesh

www.csisa.org

What is Fall Armyworm and how does it grow?

Fall Armyworm is a pest that feeds on

80 types

of plants, but prefers maize. It can be a significant threat to crop productivity.

It invaded South Asia in 2018.



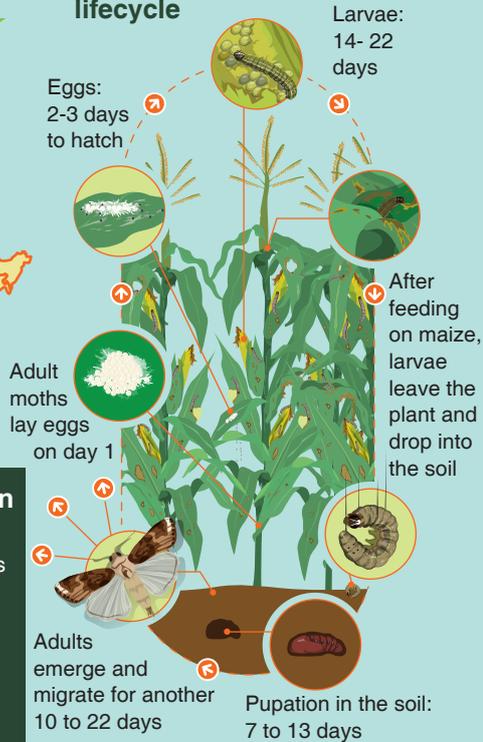
Scientists expect this pest will continue spread and cause damage.

Control in rabi season

Understanding how Fall Armyworm grows and attacks crops will help you to control this troublesome pest.



Fall Armyworm lifecycle



Fall Armyworm Life Cycle

Fall Armyworm generations last between around 33 to 63 days depending on the temperature

1 Adult female Fall Armyworm moths lay between 100 to 2,000 eggs.

2 After hatching from eggs, Fall Armyworm larvae will feed on maize for between 14 to 22 days. It eats leaves, stems, or on older plants, may tunnel directly into the maize cob.

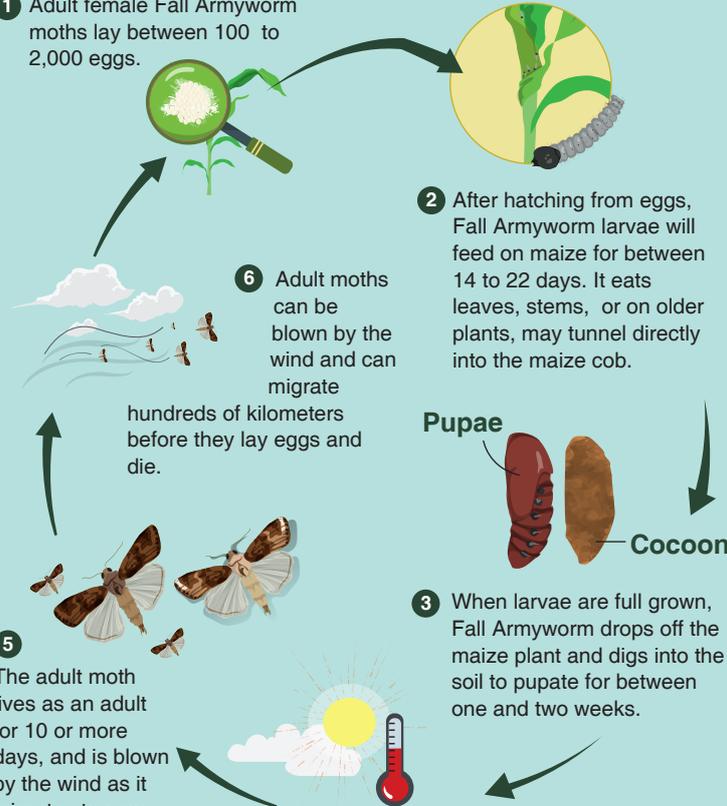
6 Adult moths can be blown by the wind and can migrate hundreds of kilometers before they lay eggs and die.

Pupae
Cocoon

3 When larvae are full grown, Fall Armyworm drops off the maize plant and digs into the soil to pupate for between one and two weeks.

5 The adult moth lives as an adult for 10 or more days, and is blown by the wind as it migrates to new fields. It lays eggs for 3-4 days while it is an adult.

4 Fall Armyworm will complete pupation and have a faster life cycle in warmer climates.



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How can you control Fall Armyworm at different stages of growth?

Look for egg masses. They are usually on the bottom of leaves. Crush them when you see them.



Fall Armyworm is most successfully controlled when it

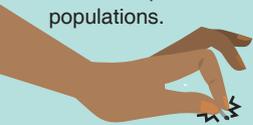


less than **10 days old**



so scout your field early and often.

If you regularly inspect your fields, larvae can be picked off plants and crushed with your hands. This will not completely control the pest, but will help to reduce populations.



Intercropping can help confuse Fall Armyworm and reduce infestation.

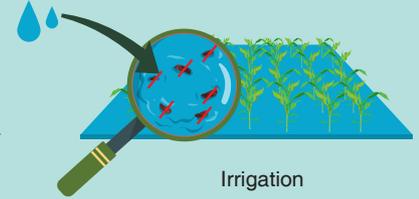


Intercropping

If you have irrigation, you can flood your field with a few centimeters of water when Fall Armyworm is pupating in the soil. Pupae will drown and die. Irrigation works best when all farmers in an area flood at a similar time. This reduces populations over a large areas where maize is grown, and helps many farmers benefit by reducing area-wide pest levels.



Without irrigation



Irrigation

Conserve spiders and other insects that are parasitic and lay their eggs inside Fall Armyworm eggs and also larvae. These spiders and insects are friends of farmers and will kill Fall Armyworm for you.



Insecticides should only be applied by a certified pest control specialist after you have consulted with an extension agent. Use insecticides only after all other pest management techniques have been attempted and failed. Remember, insecticides will also kill beneficial insects like spiders and parasitic wasps, so use them only as a last resort.

If you use insecticides, be sure to spray egg masses or larvae.



They may be hiding under leaves or in the maize whorl.

The Cereal Systems Initiative for South Asia (CSISA) was established in 2009. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). The content and opinions in this infographic do not necessarily reflect the views the Bill and Melinda Gates Foundation, USAID, or the United States Government, and shall not be used for advertising or product endorsement purposes. Correct citation: Krupnik, T.J. and Dhungana, H. 2019. What is Fall Armyworm and How Does it Grow? International Maize and Wheat Improvement Center. Dhaka, Bangladesh

International Maize and Wheat Improvement Center (CIMMYT).

Office: House 10/B, Road 53, Gulshan-2, Dhaka, 1213, Bangladesh

www.csisa.org

What is Fall Armyworm and how can I scout for it in my field?

1 Begin scouting your field soon after maize has emerged. Fall Armyworm prefers to feed at night. For this reason, scouting very early in the morning is best.

Fall Armyworm is a serious pest that can feed on over

80 plants

but prefers to eat maize.



2 Check plants for damage from Fall Armyworm.



Fall Armyworm is now found in South and East Asia and requires careful management to avoid crop damage.

By counting the number of maize plants with signs of damage, you can decide how to protect your crop.



3 Egg masses are small and white colored.

Newly hatched and young larvae are about between 1 mm long. They grow to up to 45 mm as adults. **You will have more success in controlling Fall Armyworm when they are young.**

Larvae also leave behind waste when they feed.

4 Leaf damage from young Fall Armyworm looks like small windows or pinholes chewed into leaves.

6 Keep looking at least every 10 days for signs of Fall Armyworm damage.



5 Older larvae bore directly into maize cobs, but it is very hard to control them at this stage.



The Cereal Systems Initiative for South Asia (CSISA) was established in 2009. The project is led by the International Maize and Wheat Improvement Center (CIMMYT) and implemented jointly with the International Food Policy Research Institute (IFPRI) and the International Rice Research Institute (IRRI). The content and opinions in this infographic do not necessarily reflect the views of the Bill and Melinda Gates Foundation, USAID, or the United States Government, and shall not be used for advertising or product endorsement purposes. Correct citation: Krupnik, T.J. and Dhungana, H. 2019. What is Fall Armyworm and how can I scout for it in my field? International Maize and Wheat Improvement Center. Dhaka, Bangladesh.

International Maize and Wheat Improvement Center (CIMMYT).

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www.csisa.org

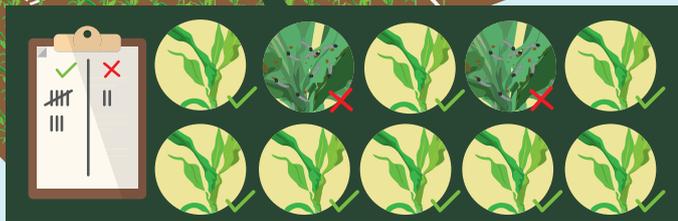
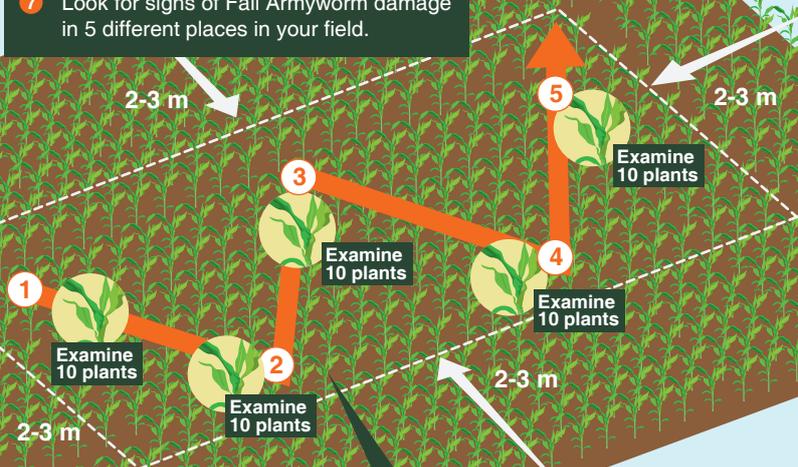
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7 Look for signs of Fall Armyworm damage in 5 different places in your field.



8 Stop in 5 places that are not on the sides of the field as shown in the image above.



10 Write down how many plants have Damage. Also record the number of plants that do not.

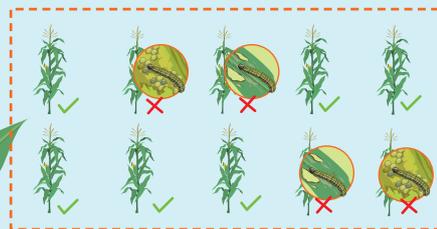


9 In each of the 5 places in your field, carefully examine 10 plants for signs of new Fall Armyworm damage. Next, count up the total number of plants out of 50 that have signs of new damage.



! If more than 10 out of 50 young plants out have signs of fresh Fall Armyworm damage, consult with an extension agent or CIMMYT for pest management advice.

11 When maize is older, examine the top three leaves or cobs for signs of Fall Armyworm damage.



If more than 20 out of 50 older plants have counted have fresh Fall Armyworm damage, consult with an extension agent or CIMMYT. Be sure to only count plants with new damage.



12 If you have found enough Fall Armyworm damage in your field, consult with an extension agent for advice.

More than 10
young plants out of 50
plants surveyed.



More than 20
older plants out of 50
plants surveyed.

13 Ask the extension agent if it you have enough Fall Armyworm damage to justify use of insecticides. Only use insecticides as a last option. If rain is forecasted in the coming days, spraying may not be needed. But if you do choose to spray, only use insecticides that minimize environmental damage and risk to human health.



What is Fall Armyworm and why is it a threat ?



Fall Armyworm is a pest that feeds on

80
types



of crops and plants, but prefers maize.



Fall Armyworm was found for the first time in Asia in 2018 in India.

Knowing how to identify Fall Armyworm is key to the fight against this pest. This guide provides simple information on how you can identify Fall Armyworm at different ages.



It has now spread throughout many parts of India and has entered Bangladesh.

Scientists expect this pest will continue to spread throughout Asia.



Damaged maize whorl



Fall Armyworm eating maize leaves



Fall Armyworm may leave behind red-orange colored 'frass' after eating



Fall Armyworm damaging a maize cob

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RESEARCH PROGRAM ON
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How can I identify Fall Armyworm?

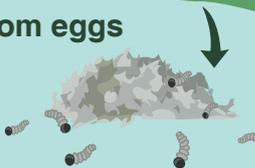
Egg masses

Egg masses are very small and white, and are often found on the underside of leaves.



Hatching from eggs

When the eggs are ready to hatch, they are a similar color as cigarette ash.

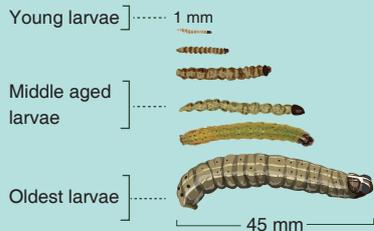


Young Fall Armyworms

Hundreds of small Fall Armyworms with black heads will crawl out of hatched egg masses.



Growing Fall Armyworm



Older Fall Armyworm

Older Fall Armyworms can have a white mark on their heads



End of adult larvae body

Head

They also have **four large dots** in a square on the end of their body.

Pupae are red-brown color



Red - brown colored Fall Armyworm pupae can be found in the soil before Fall Armyworm turns into an adult.

You may also find cocoons 2 to 8 cm deep in the soil that look like this.



Adult moth

Adult male moths have a white spot at the end of their wings.



Female moths are less colorful and do not have a white stripe on their wings

